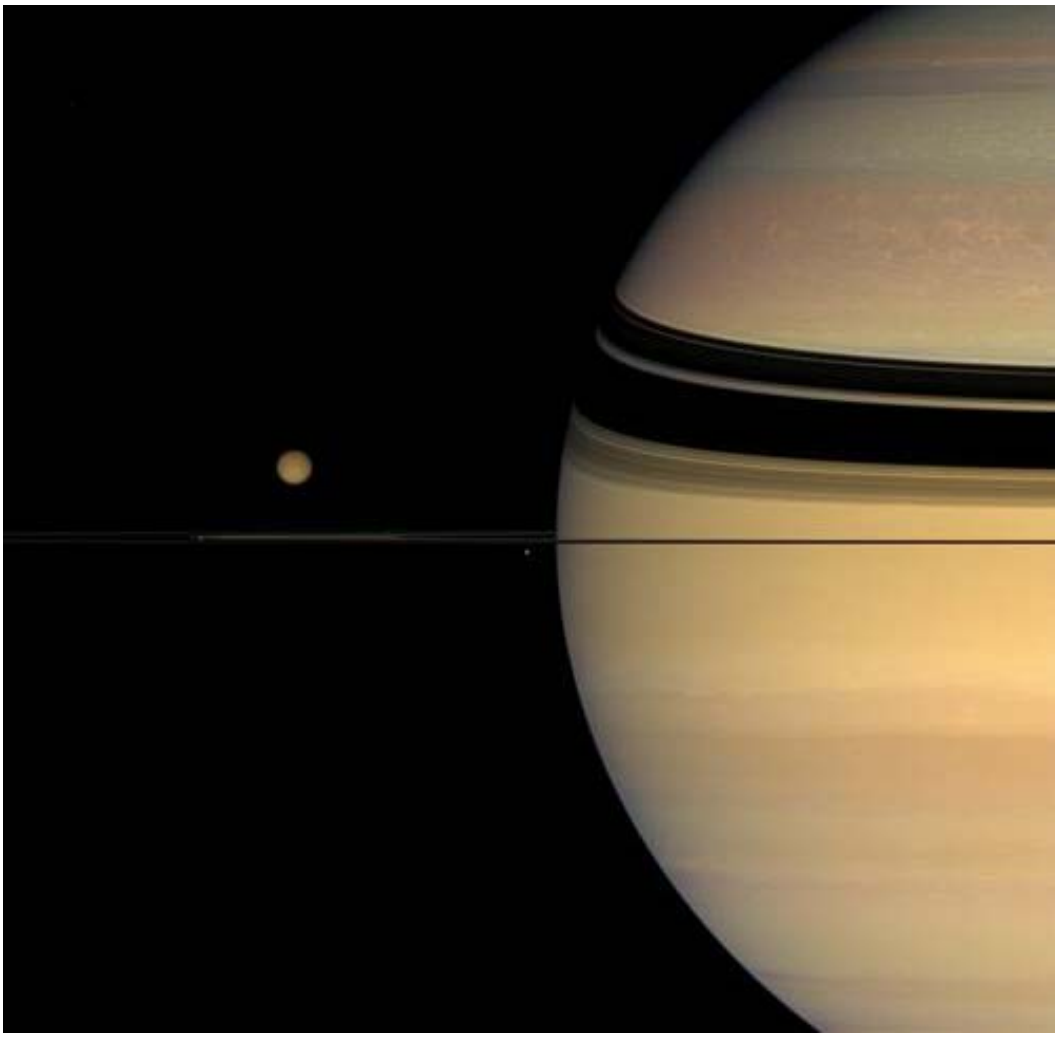
C A S S I N I



T I T A N **0 9 3 T I (T 4 7)** MISSION DESCRIPTION

November 19, 2008

Jet Propulsion Laboratory
California Institute of Technology

Cover image Many Colors, Many Moons - October 9, 2008 Four moons huddle near Saturn's multi-hued disk. The coloration of the planet's northern hemisphere has changed noticeably since the Cassini spacecraft's arrival in orbit in mid-2004. Imaging scientists are working to understand the causes of this change, which is suspected to be a seasonal effect.

Giant Titan (5,150 kilometers, or 3,200 miles across), with its darker winter hemisphere, dominates the smaller moons in the scene. Beneath and left of Titan is Janus (181 kilometers, or 113 miles across). Mimas (397 kilometers, or 247 miles across) appears as a bright dot close to the planet and beneath the rings. Prometheus (102 kilometers, or 63 miles across) is a faint speck hugging the rings between the two small moons. This view looks toward the unilluminated side of the rings from less than a degree above the ringplane.

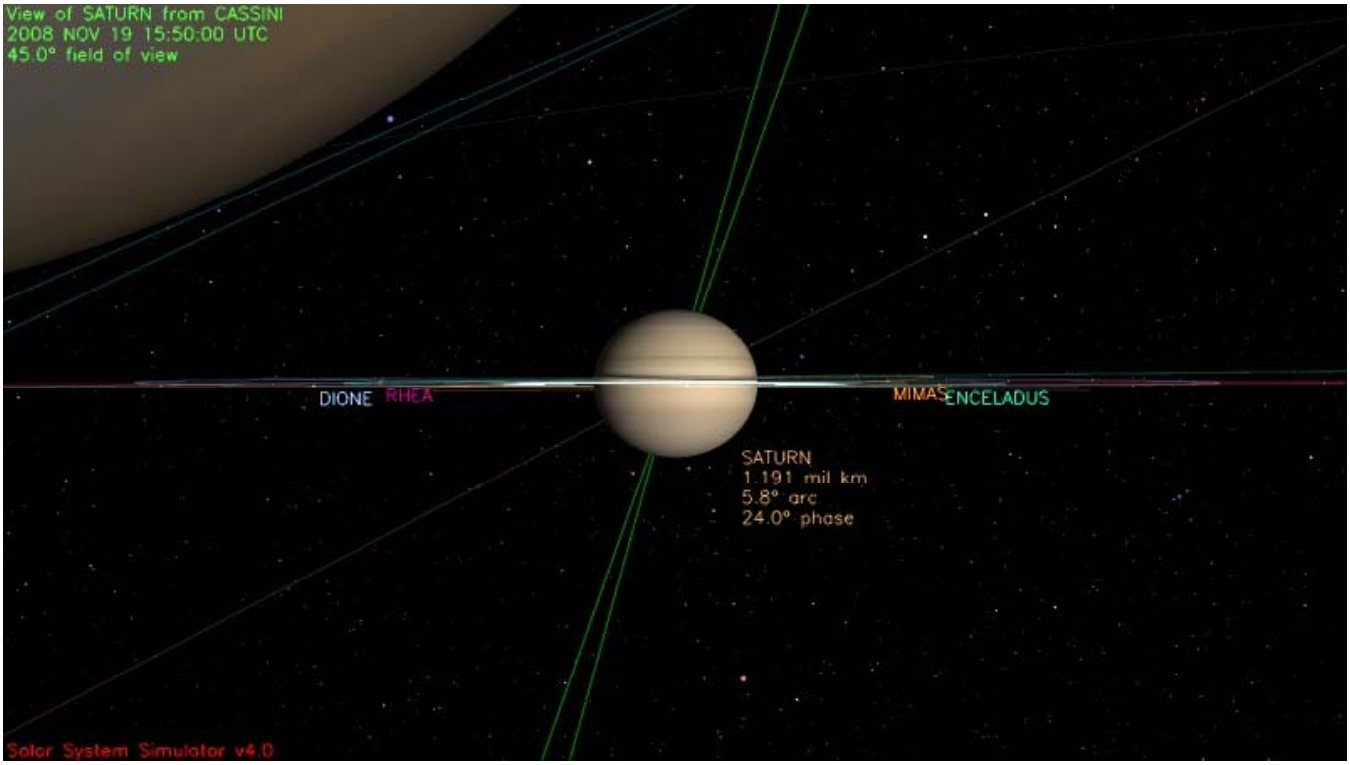
Images taken using red, green and blue spectral filters were combined to create this natural color view. The view was acquired with the Cassini spacecraft wide-angle camera on Oct. 26, 2007, at a distance of approximately 1.5 million kilometers (920,000 miles) from Saturn and 2.7 million kilometers (1.7 million miles) from Titan. Image scale is 89 kilometers (55 miles) per pixel on Saturn and 164 kilometers (102 miles) per pixel on Titan. Credit: NASA/JPL/Space Science Institute

1.0 OVERVIEW

Only sixteen days after its previous visit, Cassini once again approaches Saturn's largest moon for the mission's forty-eighth targeted encounter with Titan. The closest approach to Titan occurs on Wednesday, November 19, at 2008-324T15:56:28 spacecraft time at an altitude of 1022.6 kilometers (~635 miles) above the surface and at a speed of 6.3 kilometers per second (14,000 mph). The latitude at closest approach is 21.6 degrees S and the encounter occurs on orbit number 93.

This encounter is set up with two maneuvers: an apoapsis maneuver on November 12, and a Titan approach maneuver, scheduled for November 16. T47 is the eleventh in a series of outbound encounters and the third Titan encounter in Cassini's Solstice Mission. It occurs just under three days after Saturn closest approach.

Titan is directly between Cassini and Saturn at the time of closest approach, so the images show the view of Saturn from the spacecraft 5 minutes before closest approach, and then the view of Saturn at the time of closest approach.


View of SATURN from CASSINI
2008 NOV 19 15:50:00 UTC
45.0° field of view
DIONE
RHEA
MIMAS
ENCELADUS
SATURN
1.191 mil km
5.8° arc
24.0° phase
Solar System Simulator v4.0


View of SATURN from CASSINI
2008 NOV 19 15:55:00 UTC
45.0° field of view
Solar System Simulator v4.0

ABOUT TITAN

If Titan were a planet, it would likely stand out as the most important planet in the solar system for humans to explore. Titan, the size of a terrestrial planet, has a dense atmosphere of nitrogen and methane and a surface covered with organic material. It is Titan that is arguably Earth's sister world and the Cassini-Huygens mission considers Titan among its highest priorities.

Although it is far colder and lacks liquid water, the chemical composition of Titan's atmosphere resembles that of early Earth. This, along with the organic chemistry that takes place in Titan's atmosphere, prompts scientists to believe that Titan could provide a laboratory for seeking insight into the origins of life on Earth. Data from the Huygens probe, which touched down on Titan's surface in January 2005, and the Cassini orbiter has shown that many of the processes that occur on Earth also apparently take place on Titan – wind, rain, volcanism, tectonic activity, as well as river channels, and drainage patterns all seem to contribute in shaping Titan's surface. However, at an inhospitable -290 degrees Fahrenheit (-179 degrees Celsius), the chemistry that drives these processes is fundamentally different from Earth's. For example it is methane that performs many of the same functions on Titan that water does on Earth.

The Huygens probe landed near a bright region now called Adiri, and photographed light hills with dark river beds that empty into a dark plain. It was believed that this dark plain could be a lake or at least a muddy material, but it is now known that Huygens landed in the dark region, and it is solid. Scientists believe it only rains occasionally on Titan, but the rains are extremely fierce when they come.

Only a small number of impact craters have been discovered. This suggests that Titan's surface is constantly being resurfaced by a fluid mixture of water and possibly ammonia, believed to be expelled from volcanoes and hot springs. Some surface features, such as lobate flows, appear to be volcanic structures. Volcanism is now believed to be a significant source of methane in Titan's atmosphere. However, there are no oceans of hydrocarbons as previously hypothesized. Dunes cover large areas of the surface.

The existence of oceans or lakes of liquid methane on Saturn's moon Titan was predicted more than 20 years ago. Radar and imaging data from Titan flybys have provided convincing evidence for large bodies of liquid. With Titan's colder temperatures and hydrocarbon-rich atmosphere, these lakes and seas most likely contain a combination of liquid methane and ethane (both hydrocarbons), not water.

The Cassini-Huygens mission, using wavelengths ranging from ultraviolet to radio, is methodically and consistently revealing Titan and answering long-held questions regarding

Titan's interior, surface, atmosphere, and the complex interaction with Saturn's magnetosphere. While many pieces of the puzzle are yet to be found, with each Titan flyby comes a new data set that furthers our understanding of this world as we attempt to constrain scenarios for the formation and evolution of Titan and its atmosphere.

1.1 TITAN-47 SCIENCE HIGHLIGHTS

- **VIMS**: For the first time of the Cassini mission, VIMS will be able to image the Huygens landing site at closest approach with a resolution of less than a kilometer per pixel. It will cover areas that have already been observed with radar, allowing for a joint study of geological features including dunes and circular features that are either impact craters or volcanic calderas. Though we have a better understanding of Titan's motion, it is possible that its spin is not synchronous with its orbit around Saturn. If VIMS observations don't show the Huygens landing site, this will add to our understanding of Titan's spin rate. During the stellar occultations before and after closest approach, VIMS will get information on the atmospheric composition.
- **UVIS** will observe two stellar occultations (Eta Ursa Majoris and Beta Canis Majoris). These give vertical profiles of hydrocarbons and aerosols in the high stratosphere and mesosphere, a region that cannot be probed by other instruments. Over the course of the mission and XM UVIS stellar occultations will sample about 12 latitudes and this sampling will help constrain photochemistry, dynamics and aerosol microphysical processes in the upper stratosphere and mesosphere.
- **CIRS**: On T47 CIRS focuses on limb sounding of Titan at low latitudes, designed to measure the spatial variations of trace gas species and isotopic ratios of C, H, N and O, yielding insights into the formation and ongoing evolution of the atmosphere. In addition, CIRS continues its campaign of mapping the planet in the mid and far-infrared to obtain the spatial and temporal variation of temperature and more abundant hydrocarbon and nitrile molecules, which provide information on seasonal changes in weather, climate and chemistry that may be occurring.
- **INMS** will be trying something new: riding along with VIMS to measure the dayside ionosphere at low/equatorial southern latitudes. The instrument should get a good sampling of ions; it will miss corotation, but we should see the boundary when we hit Titan's atmosphere, which is interesting for a variety of reasons. This flyby is our first look at low equatorial southern latitudes. It's also a relatively rare dayside pass.
- **ISS** will carry out a global mapping and photometry of leading hemisphere and ride-along with VIMS for global- and regional-scale images. The areas included in the mapping are eastern Xanadu, including Hotei Arcus, the Xanadu-Fensal/Aztlan boundary, and western Tsegihi.

- **MIMI:** This should be a rare Titan encounter for MIMI for which the INCA FOV remains free of sunlight contamination throughout the pass, good for seeing the energetic ion absorption both inbound and outbound. It is also another opportunity for possibly encountering Titan outside the magnetopause, acondition we have, to date only seen for a partial encounter

- **MAG**: T47 is a flank-out flyby with a minimum altitude of 1000 km. The geometry of this flyby makes it complementary to T46 in the study of the draping of the external magnetic field around Titan by covering the dayside hemisphere. T47 takes place in Saturn's near-noon sector (10.5 hours SLT), where Titan could be found in the magnetosheath if the solar wind pressure is high. This is a first priority flyby for MAG.

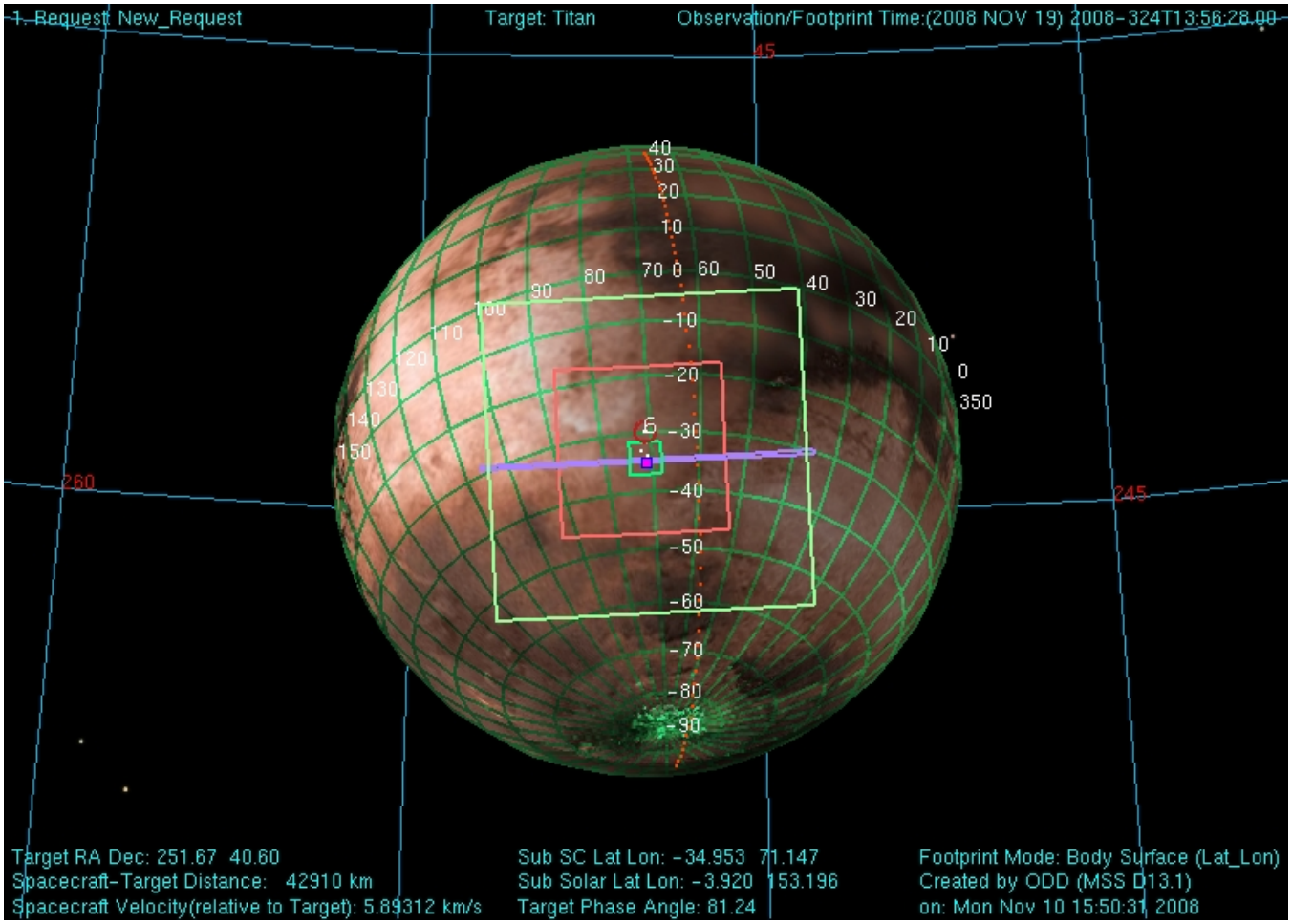
SAMPLE SNAPSHOTS

Three views of Titan from Cassini before, during, and after closest approach to Titan are shown below. The views are oriented such that the direction towards the top of the page is aligned with the Titan North Pole. The optical remote sensing instruments' fields of view are shown assuming they are pointed towards the center of Titan. The sizes of these fields of view vary as a function of the distance between Cassini and Titan. A key for use in identifying the remote sensing instruments fields of view in the figures is listed at the top of the next page.

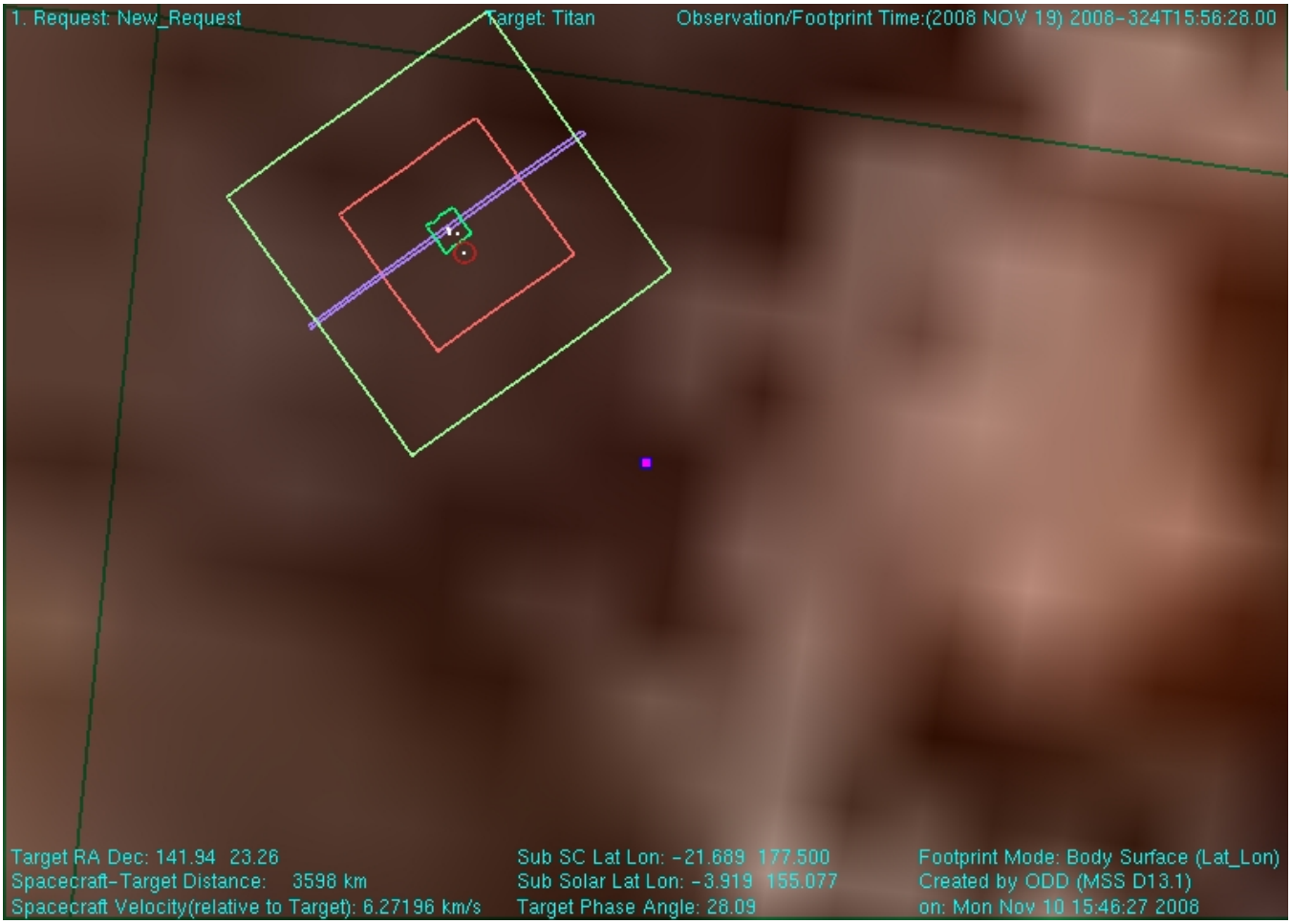
Key to ORS Instrument Fields of View in Figures

Instrument Field of View	Depiction in Figure
ISS WAC (imaging wide angle camera)	Largest square
VIMS (visual and infrared mapping spectrometer)	Next largest pink square
ISS NAC (imaging narrow angle camera)	Smallest green square
CIRS (composite infrared spectrometer) – Focal Plane 1	Small red circle near ISS_NAC FOV
UVIS (ultraviolet imaging spectrometer)	Vertical purple rectangle centered within largest square

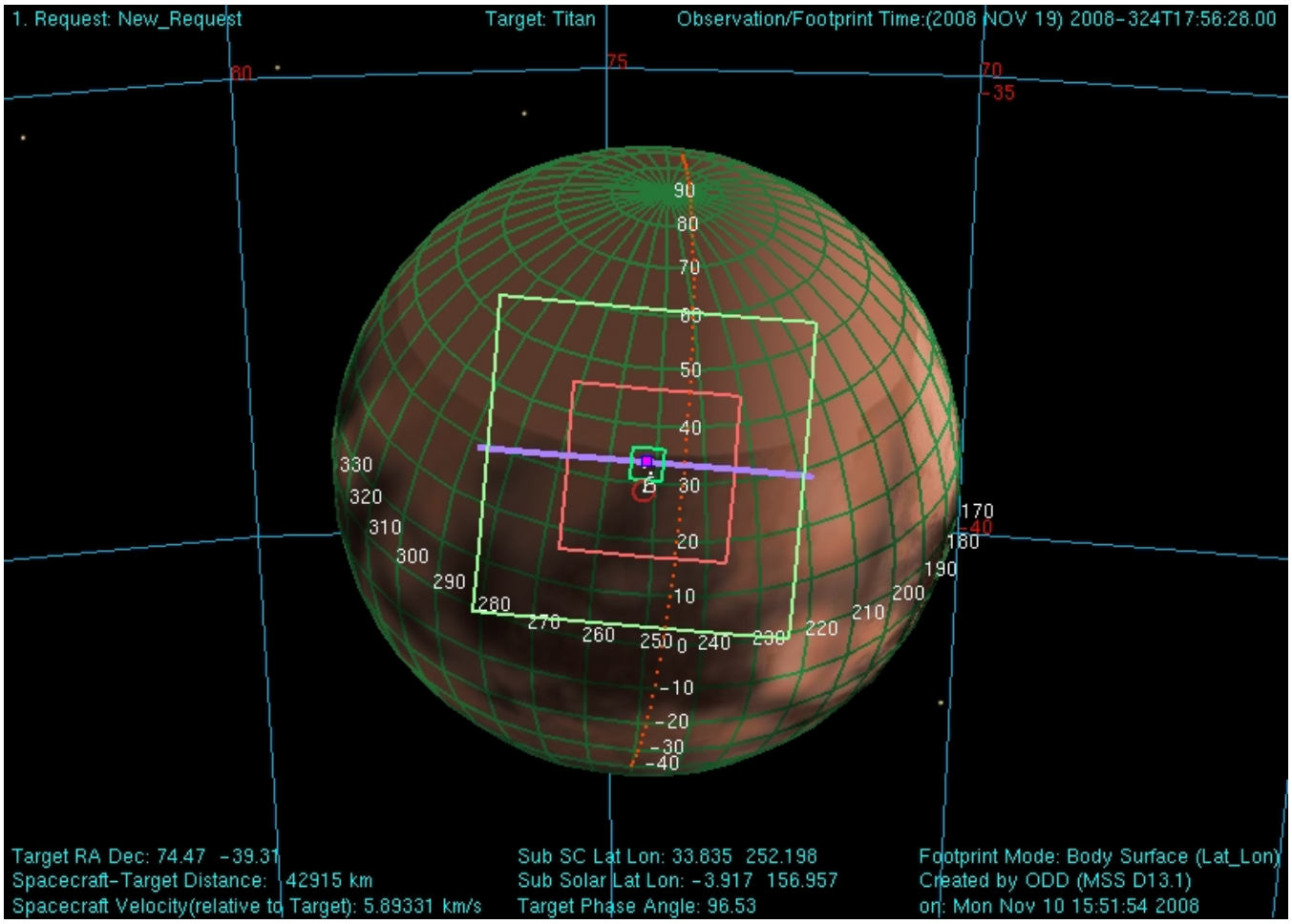
View of Titan from Cassini two hours before Titan-47 closest approach



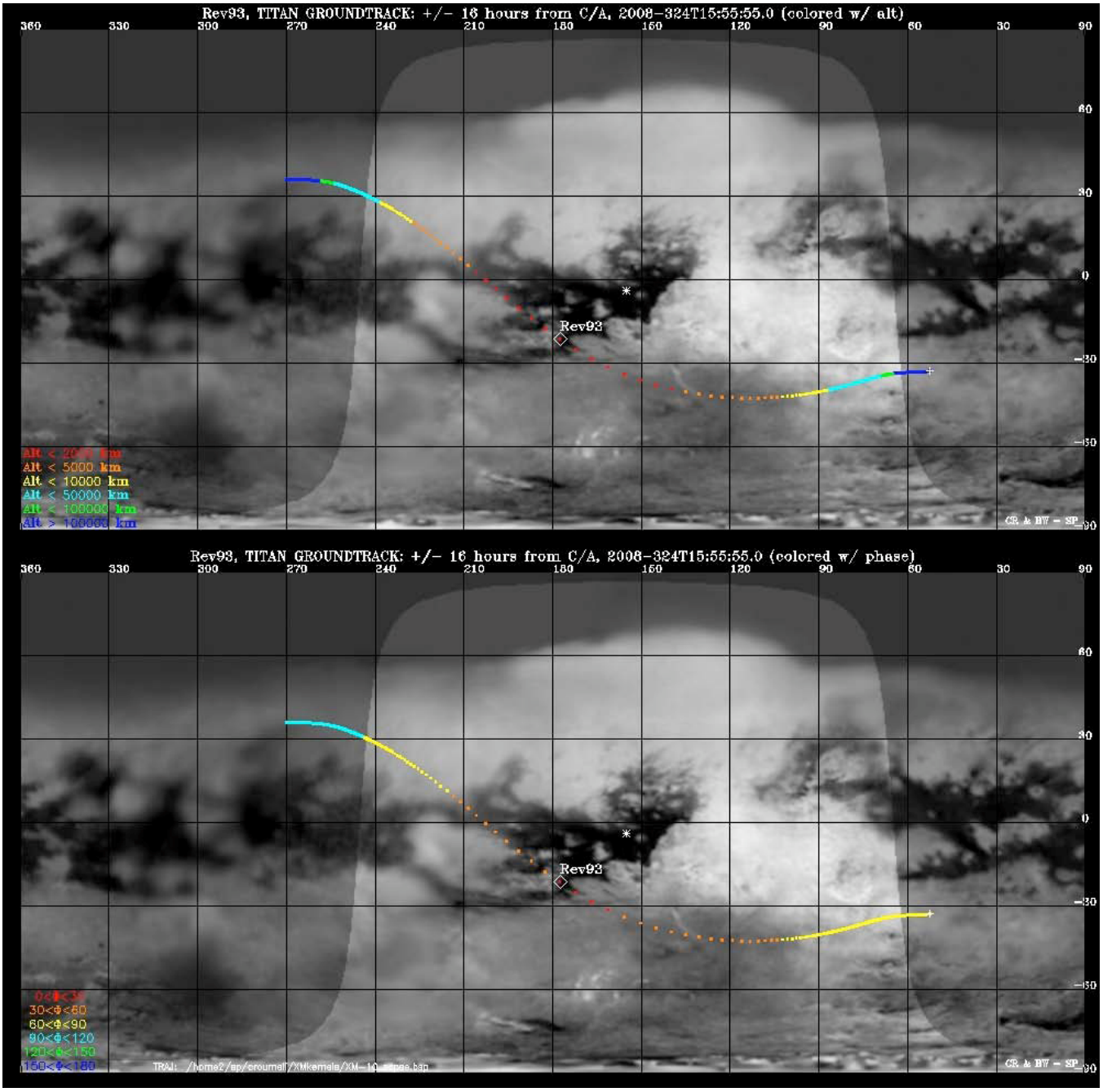
View of Titan from Cassini at Titan-47 closest approach



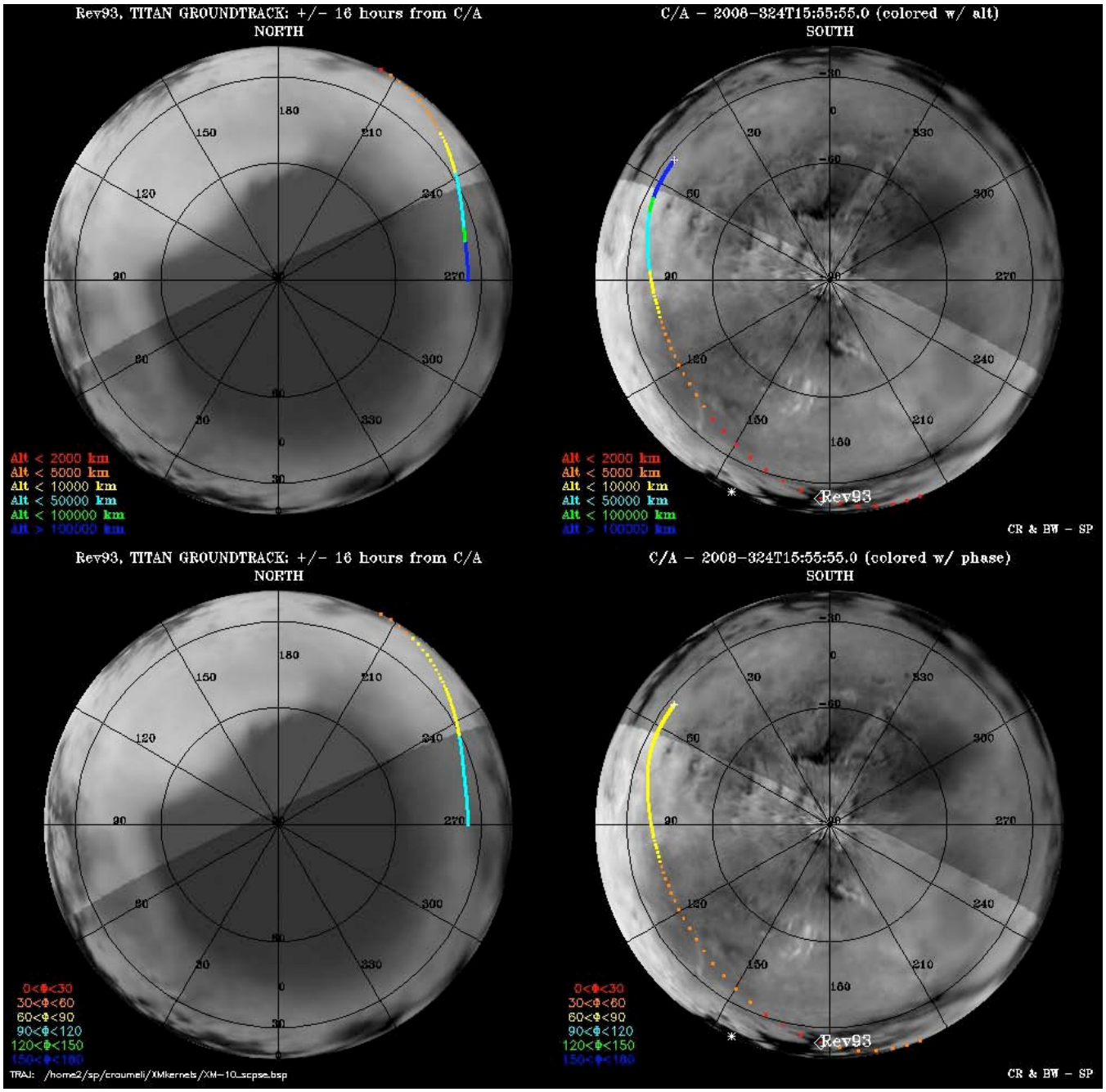
View of Titan from Cassini two hours after Titan-47 closest approach



Titan Groundtracks for T47: Global Plot



Titan Groundtracks for T47: Polar Plot



The T47 timeline is as follows:

Cassini Titan-47 Timeline - November 2008

Colors: yellow = maneuvers; blue = geometry; pink = T47-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time	Time wrt T47	Activity	Description
292T20:21:00	Oct 18 21:42	Sat Oct 18 01:42 PM	T47-31d20h	Start of Sequence S45	Start of Sequence which contains Titan-47
321T02:09:00	Nov 16 03:30	Sat Nov 15 07:30 PM	T47-03d14h	OTM #172 Prime	Titan-47 targeting maneuver.
322T09:24:00	Nov 17 10:45	Mon Nov 17 02:45 AM	T47-02d07h	OTM #172 Backup	
323T18:24:00	Nov 18 19:45	Tue Nov 18 11:45 AM	T47-21h32m	Start of the TOST segment	
323T18:24:00	Nov 18 19:45	Tue Nov 18 11:45 AM	T47-21h32m	Turn cameras to Titan	
323T18:24:00	Nov 18 19:45	Tue Nov 18 11:45 AM	T47-21h32m	New waypoint	
323T19:04:00	Nov 18 20:25	Tue Nov 18 12:25 PM	T47-20h52m	Deadtime	15 minutes 0 seconds long; used to accommodate changes in flyby time
323T19:19:00	Nov 18 20:40	Tue Nov 18 12:40 PM	T47-20h37m	Titan atmospheric observations-VIMS	Cloud monitoring
324T02:56:28	Nov 19 04:17	Tue Nov 18 08:17 PM	T47-13h00m	Titan surface observations-VIMS	Map of Titan; monitor clouds
324T06:56:28	Nov 19 08:17	Wed Nov 19 12:17 AM	T47-09h00m	Titan surface observations-ISS	Global map
324T07:56:28	Nov 19 09:17	Wed Nov 19 01:17 AM	T47-08h00m	Titan surface observations-VIMS	Global map
324T10:56:28	Nov 19 12:17	Wed Nov 19 04:17 AM	T47-05h00m	Titan surface observations-VIMS	Regional map
324T13:56:28	Nov 19 15:17	Wed Nov 19 07:17 AM	T47-02h00m	Titan surface measurements-VIMS	Regional mosaic SouthEast of Xanadu
324T14:58:28	Nov 19 16:19	Wed Nov 19 08:19 AM	T47-00h58m	Titan atmospheric observations-UVIS	Titan Occults Eta Uma. UVIS FUV Occultation slit boresite on star for the entire time.
324T15:09:28	Nov 19 16:30	Wed Nov 19 08:30 AM	T47-00h47m	Transition to thruster control	
324T15:10:28	Nov 19 16:31	Wed Nov 19 08:31 AM	T47-00h46m	Titan atmospheric observations-UVIS	Titan Occults Eta Uma. UVIS FUV Occultation slit boresite on star for the entire time.
324T15:31:28	Nov 19 16:52	Wed Nov 19 08:52 AM	T47-00h25m	Titan surface observations-VIMS	Noodle scan followed by (64.64) cube of Landing site (-10.4,192.4W) followed by noodle scan (T20-like observations). For the pointing, it means that the primary (-Y) must be such that it points to the landing site when it starts acquiring the cube and then don't move during the noodle acquisition
324T15:56:28	**Nov 19 17:17**	**Wed Nov 19 09:17 AM**	**T47+00h00m**	**Titan-47 Flyby Closest Approach Time**	**Altitude = 1022.6 km (~635.4 miles), speed = 6.3 km/s (14,000 mph); 28 deg phase at closest approach**
324T16:20:28	Nov 19 17:41	Wed Nov 19 09:41 AM	T47+00h24m	Titan atmospheric observations-UVIS	Titan Occults Beta Cma
324T16:32:25	Nov 19 17:53	Wed Nov 19 09:53 AM	T47+00h36m	Ascending Ring Plane Crossing	
324T16:36:28	Nov 19 17:57	Wed Nov 19 09:57 AM	T47+00h40m	Transition off of thruster control	
324T16:58:28	Nov 19 18:19	Wed Nov 19 10:19 AM	T47+01h02m	Titan atmospheric observations-CIRS	Vertical sounding of stratospheric compounds on Titan, including H2O. Integrations at 2 locations on the limb displaced vertically.
324T18:11:28	Nov 19 19:32	Wed Nov 19 11:32 AM	T47+02h15m	Titan atmospheric observations-CIRS	Obtain information on surface & tropopause temperatures, and on tropospheric CH4. Scan or contiguous steps across disk.
324T20:56:28	Nov 19 22:17	Wed Nov 19 02:17 PM	T47+05h00m	Titan atmospheric observations-CIRS	Obtain vertical profiles of temperatures at composition in Titan's stratosphere, by integrating on the limb for ~4 hrs at two altitudes with Z perp to limb.
325T00:56:28	Nov 20 02:17	Wed Nov 19 06:17 PM	T47+09h00m	Titan surface observations-ISS	Monitoring for surface/atmosphere changes; attempt to see surface color variations; monitor limb hazes,
325T01:56:28	Nov 20 03:17	Wed Nov 19 07:17 PM	T47+10h00m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
325T04:56:28	Nov 20 06:17	Wed Nov 19 10:17 PM	T47+13h00m	Titan surface observations-ISS	Nightside observations
325T05:56:28	Nov 20 07:17	Wed Nov 19 11:17 PM	T47+14h00m	Titan atmospheric observations-CIRS	Obtain information on the thermal structure of Titan's stratosphere.
325T07:56:28	Nov 20 09:17	Thu Nov 20 01:17 AM	T47+16h00m	Deadtime	13 minutes 32 seconds long; used to accommodate changes in flyby time
325T08:10:00	Nov 20 09:31	Thu Nov 20 01:31 AM	T47+16h14m	Optical Navigation	
325T09:24:00	Nov 20 10:45	Thu Nov 20 02:45 AM	T47+17h28m	Turn to Earth-line	
325T09:25:00	Nov 20 10:46	Thu Nov 20 02:46 AM	T47+17h29m	Playback of T47 Data	Goldstone704m